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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, Grand Buildings, Trafalgar Square, London, S.W. 1, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

THE BRITISH WEST INDIAN SUGAR ASSOCIATION

THE decision to form a British West Indies Sugar Association was taken at the British West Indies Sugar Conference which was held in Jamaica last July. This Conference, the first of its kind, was organised by the Jamaica Sugar Manufacturers' Association largely at the instigation of the Inspector-General of Agriculture for the West Indies. The first general meeting of the new Association was held early in March in Trinidad where it was incorporated under the law of the Colony and where it will have its registered office. The Acting Commissioner of Agriculture at this College performed the duties of Secretary to the Association during its preliminary stages.

The formation of the Association is an event of considerable importance in the history of the sugar industry of the British West Indies and to anyone who is familiar with the strong individualism that has characterised British West Indian sugar interests in the past it undoubtedly represents a great achievement. For the sugar industry is so big a factor in the economic structure of the West Indies that any measures which can help to secure greater cooperation and coordination in all matters affecting the industry will be welcomed. The chief aims of the Association will be to promote and protect the sugar industry in the British West Indies, to consider and take action on any questions which may directly or indirectly affect it, to promote research and other scientific work and to disseminate information on matters of interest to the industry. The Association should provide ample scope for a free interchange of views throughout the West Indies leading to a greater understanding and knowledge of each other's difficulties. It should also be a help in laying the foundation for sounder development and for better social conditions in these Colonies.

The memorandum and articles of the Association naturally cover a very wide field and provide for the Association taking cognizance of any matter related to sugar production. No details have been published in regard to the decisions reached at the first meeting and it is therefore not possible to state definitely what subjects the

Association will concern itself with first or what its policy regarding them will be. Its first object will presumably be to coordinate the activities of existing local investigational organisations in the various islands. Of the several matters which it is likely to deal with one of the most important will undoubtedly be to negotiate on behalf of the West Indies as a whole in any future schemes for regulated marketing or for quotas of production under international agreements. The increased attention given to field and factory costings in recent years has been an important factor in the increased efficiency of the industry. Yet the diversity of conditions in the different Islands renders it difficult for a producer in one Island to compare his costs with those of a producer in another. In nearly all the Islands manurial and cultural experiments are carried out on more or less elaborate scales, yet the lack of uniformity in methods makes it difficult for sugar planters in any one Island to appreciate the work carried out in another Island. Again, referring to research—the conversion of the by-products of the sugar industry, molasses and bagasse is a subject urgently needing attention. It is known that rapid progress is being made in other countries in this direction and there is little doubt that the opportunities are much greater to-day than they were even a very few years ago. Yet the subject is far too big to be usefully undertaken by any one sugar manufacturer alone, or even by the Manufacturers' Association of any one Island. It is in such spheres that the British West Indies Sugar Association is likely to be able to help its members; and thus by increasing the profitableness and stability of the industry also to confer benefits on the West Indies as a whole.

OVERHEAD IRRIGATION OF BANANAS IN HONDURAS*

THE water is distributed through a specially designed revolving nozzle (sprinkler) at the top of a vertical 4-inch pipe. This vertical pipe is known locally as a "riser". The height of the nozzle above ground is 25 feet. It is made to revolve by the action of a jet of water on a small water wheel geared to the base of the nozzle and is adjusted so that the time required for one complete revolution may be varied. The local custom is to make one revolution about every 15 minutes. The nozzle throws a stream of water about 205 feet in length. There is a fairly even distribution of the water over the length of the stream, *i.e.* from the nozzle out to the perimeter. The area wetted in one complete revolution is 3.3 acres and water is applied over this area at the rate of $\frac{1}{3}$-inch each hour. A nozzle is normally operated for from 3 to 6 hours, giving an application of from 1 inch to 2 inches of water. The number of days from the time a nozzle is operated until it is operated again depends on climatic, soil and other conditions. The nozzle is designed to deliver 500 GPM at 90 lb. pressure at the nozzle.

On the average sized project one centrifugal pump with a discharge capacity of 3,500 GPM at a pressure of 150 lb. is used. This is powered by a Diesel engine of approximately 400 HP at 450 RPM. This 3,500-gallon pump will operate 7 nozzles simultaneously. The diameters of the pipes in the supply lines vary from 14 inches close to the pumping plant to 4 inches or 5 inches, at the risers farthest from the pump. The pipes are of cast iron and have universal joints.

Risers are spaced over the field so that they will wet circles of land tangent to each other at points 205 feet from the centres. All angles in the pipe lines are 120 degrees. All pipe lines are permanently anchored in place. The risers have to be guyed and are on a cement base.

The nozzles are detachable. Regularly two are required for each group of risers and are used alternately. While one is in operation the other is attached to the next riser that is to be operated in the group. In practice, one man can look after from 2 to 6 groups of risers. The riser pipes have steps welded to the sides for climbing up to attach the nozzle. The nozzle is made of aluminium and weighs approximately 30 pounds.

The effect of the water from the nozzle on the vegetation is about that of a very heavy rain. It might be too severe for tobacco plants and ploughed fields. As the whole installation is costly and has to be of permanent construction, it is seriously questioned whether it can be adapted to tobacco fields where, as is stated, the soil is used for tobacco only every 8 years. Perhaps a portable system of which there are some available on the market would be more suitable.

PROPOSED INTER-AMERICAN INSTITUTE OF TROPICAL AGRICULTURE

The Government of Venezuela has offered 4,000 acres of agricultural land, according to a report in "Agriculture in the Americas," for the establishment of an Inter-American Institute of Tropical Agriculture. Nothing definite can be said at present about the plans for this Institute, but it is very probable that the newly-established Agricultural Division of the Office of the Co-ordinator of Inter-American Affairs in Washington is working out plans for its foundation and development. Dr. E. N. Bressman, formerly with the Office of Foreign Agricultural Relations of the U.S. Dept. of Agriculture, has recently been given charge of this new division and a staff of suitable collaborators is now being selected.—(*Chronica Botanica*, Vol. VI, p. 454.)

* This note is published by courtesy of the United Fruit Company to which our acknowledgments are due.

THE LOW TEMPERATURE RESEARCH STATION, 1936-1941

Introduction

Another milestone in the progress of the Low Temperature Research Station has been passed with the conclusion of the five year grant, October 1st, 1936 to September 30th, 1941, from the Colonial Development Fund. This brief account is intended as a record of those of its activities and achievements not already covered by publications from the Station, and of the functioning of the installation as modified under the terms of the grant. A brief survey of some of the results of the first seven years of low temperature research in Trinidad was given at the Imperial Botanical Conference in 1935, (1).

Operation of the Station

The grant included a capital sum for the provision of laboratory accommodation, till then lacking, and for effecting certain necessary repairs and minor alterations to the cold storage plant and rooms. These have been described and illustrated in a publication, (2).

Owing to the necessity for revising the plan of alterations to the storage rooms and to interruption of the supply of cork from Spain the plant was not available for running until November, 1937.

The alterations effected have been of considerable benefit. The subdivided ripening room with independent brine supply, provides for experiments on contrasting ripening conditions but in the portion without special humidity control the humidity is too low for satisfactory ripening (70 per cent. R. H. at 68°F.) whilst that in the controlled portion is subject to considerable "tracking" about the mean value. These two rooms have also been used for constant high temperature (85°F.) experiments with bananas by the use of the heater mat units without refrigeration. So far little use has been made of the facilities available for experimental ripening, as work has been concentrated on investigation of the storage period at 53°F.

The installation of suction lines to the storage rooms has made respiration experiments possible, and the system has proved adequate for the purpose. When the respiration of individual bunches of bananas is undertaken a supply of compressed air will be necessary.

The freezing room, adapted from the original meat storage locker, has proved capable of giving temperatures of -25°F., with -40°F. in the freezing box. Banana pulp can thus be frozen hard in 3 to 4 hours. It is expensive to run this room as the stand-by compressor is required to run continuously; so that its utility has been severely limited under the Station's restricted budget.

It should be noted that complete modernisation was not possible within the limits of the grant and that the Station's equipment cannot yet reproduce conditions comparable with those in the holds of modern banana boats, in particular as regards rate of cooling, humidity control and adjustment of volume of air delivered, nor is the accuracy of control of temperature as high as desirable in a station designed to improve on existing practice, whilst the humidity in all rooms (approx. 80 per cent. at 53°F.) except that with special control, is lower than that on ship board and, further, fluctuates very considerably with the secular changes in brine temperature. Shortcomings are also evident in the engine-room equipment and frequent occasions of anxiety have occurred during refrigeration runs.

These defects are largely due to the fact that the budget was originally prepared to meet a programme of empirical work and no opportunity was provided for its revision in preparation for the more exacting conditions required in fundamental studies.

The intermittent running of the Station has again resulted in the need for frequent repairs due to corrosion and deposition of scale in the room cooler-coils during shut-down periods.

Programme and Publications

The programme laid down called for a concentration upon fundamental researches with particular reference to the banana, not to preclude work of an *ad hoc* nature where such was necessary and desirable. This was carried on during the first four years of the grant by three members of staff (Officer-in-Charge and Pathologist, Plant Physiologist, and Biochemist) and a considerable volume of work of fundamental and practical importance has resulted. Some of this has reached the stage of publication and has appeared as a series of ten papers in the *Annals of Bo any*, reissued as memoirs (for one of which Mrs. Barnell was responsible), five memoirs on practical aspects, a comprehensive account of the storage of tropical fruits and vegetables compiled from the literature and various contributions of a popular nature to *Tropical Agriculture*.

Empirical storage trials have been carried out on citrus with special reference to antiseptic and other treatments prior to storage and on avocados and also with the College hybrid banana, I.C. 2. and of Gros Michel bunches from plants with various degrees of attack by banana leaf spot disease (*Cercospora musae*). Additional experiments on the incidence of chilling in bananas have been made.

The investigations on the metabolism of Gros Michel bananas have prepared the way for storage in controlled atmospheres (refrigerated "gas storage") and a memoir indicating the progress achieved has been published. A confidential report has also been prepared describing experiments on a pre-storage treatment of bananas designed to extend the storage period.

Liaison and Conferences

Dr. Wardlaw represented the Station at the International Horticultural Congress in Berlin, 1938, and read two papers, and also prepared a paper in collaboration with the Mycology Department for submission to the Imperial Mycological Conference in London in 1939, which was abandoned on the outbreak of war. He also represented the Station and read a paper to Commission VI of the International Institute of Refrigeration in London in 1938; another paper was read on the Station's behalf at a meeting of the British Association of Refrigeration in London in 1939. A report on the Station's activities was also given to the West Indies Fruit and Vegetable Conference, 1938.

Advisory Activities and Visits

Dr. Wardlaw and the College Engineer paid a visit to Bermuda in 1937 to advise on the erection of a Government pre-cooling plant and cold store for the dockside site at Hamilton.

In his capacity as Banana Pathologist, Dr. Wardlaw made a considerable field study of the leaf spot of bananas due to *Cercospora musae* with respect to its incidence and to varietal resistance and made extensive tours of Jamaica and the Republic of Honduras to study the methods of control of this disease as used by the United Fruit Company (1940). He also paid visits to Guadeloupe (1937, 1938 and 1939), Haiti (1938 and 1940) and Dominica (1938) in connection with banana diseases. He followed up the visits to Guadeloupe by a visit to see bananas from the West Indies on arrival in France and during ripening in that country.

Contact has been maintained with the different shipping companies in the Caribbean through visits to ships by members of staff and by return visits of the ships' engineers and employees of the United Fruit Company to the Station; and an investigation of temperatures and gas concentrations in a modern type of banana boat was made. A survey of the distribution and ripening of bananas from the British West Indies in Canada was also made. The station has also been consulted by the Trinidad Department of Agriculture in connection with the building of a citrus pre-cooling store, a cold storage room for "ground provisions" and a scheme for reorganizing the local fishing industry.

Whilst on leave members of the staff have maintained contact with the Cambridge Low Temperature Research Station, the Ditton Laboratory and the Covent Garden Laboratory of the Food Investigation Board, and the Imperial Bureau of Horticulture and Plantation Crops. The opportunity has also been taken during periods of leave to visit the National Physical Laboratory, the Low Temperature Research Laboratory, Capetown, and the principal research stations in Canada at which cold storage problems of fruits and vegetables are being studied.

Future Programme

On the recommendation of the Comptroller for Development and Welfare for the West Indies a grant for the maintenance of the Station for two years has been made under the Colonial Development and Welfare Act, 1940. This will enable the reduced staff (two) to continue experiments on the improvement of the storage of bananas. It is very much to be hoped, however, that, as soon as more settled world conditions are brought about, opportunity will be given to revise the whole status and scheme of operation of the Station. Only by taking a broad view of the problems of food conservation in the Tropics can rational and economic use of its facilities be made and some of the great potentialities of refrigeration in the Tropics be realised.

Acknowledgments

During the first four years of the grant now expired the Station was in the charge of Dr. Wardlaw, who became Professor of Cryptogamic Botany in the University of Manchester in October, 1940. He was responsible, in consultation with the Low Temperature Sub-Committee of the Colonial Advisory Council of Agriculture and Animal Health, for the preparation of the Station's programme.

Assistance with supplies of fruit has been given by local planters especially Mr. Robert de Verteuil and Mr. Jack Hutton for bananas, and Mr. Barnardo and Dr. Mason for grapefruit. The Trinidad Department of Agriculture, and in particular the Superintendent of River Estate and the Banana Officer, have rendered great assistance in arranging for supplies and the Co-operative Citrus Growers' Association with facilities for grapefruit experiments. To all of these grateful thanks are due.

The various alterations and the operation of the refrigeration plant have been carried out under the supervision of the College Engineer. The very restricted grant for reconstruction, the difficult working schedule of the Station (short intermittent runs with considerable idle periods) and the frequent changes in the three unqualified local operators of the refrigeration plant, which when running constitutes the major load on the College electrical plant, have made his task a very difficult one and it is to his credit that only minor technical troubles have occurred.

Finally, the local assistant staff (four) during the five year period acquitted themselves very well in the varied technique of the Station and it is greatly to be regretted that none of the original members is now available.

E. R. L.

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(1) Wardlaw, C. W. and Leonard, E. R.—The Storage and Physiology of Tropical Fruits. *Tropical Agriculture*, XII, 12, 313–319, 1935.

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EXPERIMENTAL BREEDING OF DAIRY CATTLE FOR THE TROPICS

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Introduction

IN the summer of 1941 the writer made a tour of the South Eastern part of the United States of America. He visited the King Ranch at Kingsville, property of the Kleberg family, and met Congressman Richard Kleberg and Dr. Northway. He saw the Brahman (Zebu) herd at Hungerford, property of Mr. Hudgin; the Jeanerette Station, Louisiana—Mr. Rhoad; and met Professor Williams and staff at the Texas A. & M. College; officers of the Federal Department of Agriculture at Washington D.C. and Beltsville, Md.; and finally Dr. Becker and officers of the Experiment Station at Gainesville, Florida. To these gentlemen he is much indebted.

The main object of this tour was to enquire into dairy cattle and their management, feeding and breeding, under sub-tropical conditions, especially from the aspect of nutrition where maximum use is made of home grown foods. Hence forage and fodder crops were of considerable interest. At the same time, knowing how artificial a life is led by good milking cattle in the tropics, the writer wanted to learn whether any attempt had been made to breed or to select a dairy cow more suited to cope with or bear conditions of heat and humidity such as are met with in the tropics, and therefore, one able to be kept under more nearly average conditions, comparable with those under which dairy cattle are kept elsewhere. It is generally realised that the greater the artificial aid used to bolster up milk production, the higher the expense; all the factors which operate to reduce the efficiency of the dairy cow in the more tropical countries are not even yet known.

Thus the work done at the King Ranch in evolving a type of beef animal more suited to conditions in that part of Texas than high grade or pure bred Shorthorns and Herefords; and Rhoad's painstaking researches at Jeanerette concerning the behaviour of various types and crosses of livestock under conditions of heat and humidity, were of particular interest. This work all relates rather to animals kept for breeding and beef, the milk-producing side having not yet figured in the work, at least not in any way directly. The work current in the South Eastern United States in connection with pasture, forage and fodder, and especially that concerned with vital mineral elements, vitamins and parasites fits well into the picture, and undoubtedly is going to be of increasing service in helping the farmer to surmount some of the admittedly greater difficulties of dairy farming in the more nearly true tropics: Panama, the West Indies, Colombia and countries in which conditions are akin.

The Problem

One of the greatest bugbears of cattle farmers in tropical areas is how to breed to maintain virility, size, and the attributes of improved cattle breeds under conditions which vary so very much from those in which the breeds were evolved and established. In the past cattle improvement has gone hand in hand with the improvement in availability and quality of foodstuffs and methods of feeding employed; the yield of milk or of beef keeping pace at least with the extra effort made by the farmer. The standard of production has thus been steadily raised but efforts still are constantly being made everywhere to meet the nutritional requirements of cattle within reason and knowledge, and economically enough to ensure profits. Even then in tropical areas, from causes which were, and in many cases still are obscure, they have failed, and here the work being done in examining the rôle of minor elements and vitamins and on parasites, is of importance. But with all this and bearing in mind the breeding work which has been done and the researches of Rhoad, is it certain that we can ever accept as the dairy animal for the tropics a breed or breeds originally evolved in more temperate climes where natural conditions are so different and the range of foodstuffs which may be grown, including the composition of the pasturage, is so varied, and where rainfall and heat have not so profoundly affected soil composition?

There are Asiatic cattle, admittedly not what could be called real dairy cattle, which, under ordinary and reasonably good conditions of feeding, do reproduce, thrive and give moderate to low milk yields in conditions of heat and humidity. They have been used with some measure of success in tropical areas in crossing with beef and dairy breeds evolved in temperate zones, for the purpose of imparting vigour, while considerable success has attended their use with beef breeds for ranching purposes. In the Santa Gertrudis selection something exists which is not just a cross, but rather in the nature of a breed in that animals of this selection, when interbred, reproduce themselves with but little variation from the average. The sooner this selection is described and its character and characteristics settled the better. Whilst it is said that nowhere does this Texas selection do so well as in the zone in which it was evolved, this does not in the author's view vitiate any claim which may be made to have it recognised as a breed. Were there one hundred thousand representatives of this selection, behaving reasonably as a pure breed, it would be recognised as a breed without hesitation.

What must be realised is that the system of crossing between breeds to produce a crossbred dairy animal does not take one far; the crossbred dairy cow herself, being a cross bred, deliberately produced as a cross, is of no particular importance as a breeding cow. But, if as a result of breeding within the cross and subsequent selection, a blend of blood which carries the desirable characteristics were isolated and concentrated by breeding artifice, as was done with the Santa Gertrudis, then something might be achieved. This work will have to be done deliberately. No doubt bulls and cows are being produced every year which could be used as the basis for a breed, but in the nature of things these individuals are lost or are never discovered and tested.

What would be contemplated is the mingling of "European" dairy blood with what can be termed "heat resisting" blood—with a view to isolating a suitable blend, and then concentrating the blood of the blend so that it can be bred pretty nearly true, eliminating by rigid selection any tendency to diverge from the original purpose and ideal, and finally isolating a group of individuals which will breed together in usual conformity.

What material exists, and how it should be used, is the next question.

Indigenous herds of cattle in India have, for countless generations, been bred and reared under conditions of high heat and some humidity and often are used to short commons. In Africa, too, there are animals, presumably descendants of cattle of the same generic type as Indian or Zebu cattle, but as a rule they are not so well defined as breeds. In South Africa, from the indigenous red Trek Ox type, specially sorted and matched mainly for hauling purposes, a more or less uniform type called the Afrikander has been selected, and today is there recognised as a breed. Several enthusiastic South African breeders have been careful to select and breed herds of Afrikanders for milking capacity. In India there is a deliberate attempt to gather together into groups specimens which may ultimately be bred into dairy or milking stock. In parts of Africa attempts, on a quite inadequate scale, are being made to select groups of indigenous cattle showing milking tendencies, but much remains to be done. The main reason why it is considered important to select from the indigenous cattle is because they have the ability to withstand the conditions and the endemic diseases prevalent in the country: the more European blood which is infused, the lower the ratio of recovery of calves from East Coast Fever infection, for instance. Thus, today, it is not easy to secure animals with heat resisting ability, which at the same time are renowned for milking capacity.

Rhoad has demonstrated, from data secured in studying respiration rates, sweat production and rise in temperature due to exposure to the direct rays of strong sunlight, that types of animals group themselves in his list in direct proportion to the "amount" of Indian or Zebu blood present. Thus the pure Brahman, a white or silver haired animal with black points, large drooping ears, often a "mealy mouth", a loose folded skin which has black pigmentation, stands out as a type least discommoded by heat and humidity. It has more numerous sweat glands. The Afrikander—(unfortunately Rhoad has too few of these animals, and the published data from the Messina (Transvaal) Experiment Station are not yet sufficiently extensive)—stands below the pure Zebu, but high enough to indicate that it is equipped for heat regulation far better than a European breed of livestock (Bos Taurus). The Jersey, in whose background there may be some of this heat resisting blood, stands higher than the Hereford, Angus or Shorthorn; and as yet insufficient work has been done on the Friesian to enable it to be placed accurately. There are, moreover, no records which might indicate why the South African farmer prefers the more nearly black coated Friesian to the whiter coated strains.

The heat resisting ability of the Jersey is to be noted, its almost typical mealy mouth can be seen dozens of times a day amongst degenerate Zebu types of cattle in Central Africa.

The tropical dairy cow might well be built up of a blend of Zebu blood, if possible with milking tendencies; and one or other or both of the better class true dairy animals—Jersey or Friesian. South Africa has its "Cape Cow" a dairy animal—resembling and possibly being actually a Friesian grade topped on a *pot pourri* of breeds of all kinds with the Hottentot cow as the original female ancestor—here there is *no known* proportion of heat resisting blood, but there is some present. The Hottentot cow more than probably figures largely in the make up of the Afrikander and it may be taken that the Hottentot cow was not unrelated to the Indian type of cattle.

But one should not fall into the groove of postulating an optimum proportion of Zebu as against temperate zone (Taurus) dairy blood. One should rather think, as did the men of Santa Gertrudis, of how to isolate a decent looking good producing type suited to the conditions, and how to concentrate that blood until a range of stock resembling a breed is obtained which can be multiplied and dealt with as a breed; namely, a number of better class herds, from which can be drawn bulls showing the best of type and performance and the best of blood, to use on specimens of the type in less productive herds.

The system of Jersey cattle breeding, the "bull testing" or the "proven bull" system adopted by the United States Department of Agriculture, whilst it takes cognisance of type and points, does not essentially rely on blood lines but on the producing performance of the daughters of a bull. This is an almost purely utilitarian approach. In other words the ability of a bull to raise or maintain in his daughters, the known productive capacity of their dams—good milking specimens of the Jersey

Breed—is a measure of the value of a bull. This ability is highly prized. Naturally the fecundity of the bull, likely length of useful life and so forth, has its place in their calculations. But until a bull, through its daughters, has demonstrated his capacity, ability and superiority, he is not a herd header. With the high standards set there is a tendency for blood lines to assert themselves, but these lines are not dominant in the breeding programme. At the Experiment Station, Gainesville, a combination of "proven utility" and "blood line" is used in the mating of the Jersey herd. So, similarly, in making the new tropical breed, bulls must be found, which, under feasible conditions of dairy herd management, will tend to throw daughters, from recorded females of type and constitution similar to the bulls; which show an advance on their dams from the butter fat or milk producing angle.

Suggested Projects

Now as to making these crosses, namely:—

(*a*) Indian type bulls on groups of milk recorded European type females, and the reciprocal.

(*b*) European type bulls of milk proven breeding capacity on groups of Indian type cows which are known as milkers.

It should be recollected that type in Zebu cattle is rather dominant, especially in project (*a*). The concentration of blood in the Zebu is comparable with the concentrated blood of European pure breeds—what is required is not the milking capacity of the Indian cow, but rather its adaptability to tropical conditions, vigour, and natural adjustment for comfort. Its actual conformation and the nervousness of its females are not wanted. What is wanted is hidden physiological ability. It is suggested that the bulls used in project (*a*) be the first cross between two distinct types of Zebu, if possible finding a good bull or bulls out of decent milking and reasonably quiet Zebu cows and using them on the best milking cows of another type or breed of Zebu, or alternatively using Afrikander-Zebu crosses.

The young bulls of this first cross should then be taken, with their presumably warring blood, and used on good recorded Jersey cows and, if at all feasible, on good recorded Friesian cows. The first record will be the fecundity of the bull, the next the extent to which the appearance of the dam is dominant and finally the heifer record for milking performance and behaviour compared with that of its dam. Within 4 to 5 years of the production of these bulls information should be available regarding the ability of a "cross bred" bull of double Zebu strain to settle known milking cows, and the extent to which his use has masked or depressed in his daughters the milking capacity as carried in their dams. That, at any rate, might indicate bulls of mixed Zebu origin which do or do not seriously interfere with the milking capacity of their daughters out of recorded cows.

Now to concentrate this Zebu + European blood it will be necessary to inbreed, and to do this at least two bulls of the cross will have to be isolated whose daughters, out of good milking cows of the same origin or cross as themselves, are not deteriorated as dairy cows relative to their mother's performances. It may be assumed with what extent of reasonableness the author is quite unaware, that a son from an original recorded cow is comparable in make up with his full sister, at any rate a son by the same bull following a good performing daughter out of a good recorded mother may be comparable with that daughter. This will not be known until these bulls are tested on the half bred daughters of the other bull, and possibly on pure bred cows of the breed. With luck and replication it may be possible to get a "half bred" which can be used to set up a new type. On the other hand this may fail utterly.

The reciprocal cross of the European type bull on Zebu × Zebu or Afrikander × Zebu heifers will need to be made. This way, European on Indian has, it is believed, the virtue of giving a more "European" looking female. Grading up should not follow, but rather an attempt be made to concentrate the blood of the best heifers from this second cross by a form of line breeding—using as bulls the full brothers of the best milking heifers. The first cross Zebu-European heifers will have to be handled in a way approximating to the handling of dairy cows; in this way, at any rate, docile animals and animals which milk reasonably well when deprived of their calves would show up. The milk records of these cross bred daughters would be almost sure to be much superior to those of their dams, and their milk records would have to be compared with known records of pure bred heifers, the daughters of the pure bred bulls used. It would mean the use of proven sires on a range of mixed Zebu heifers or cows. The object should be to get a couple of a hundred cross bred heifer calves each year for two years at least, preferably three years; and also a large number of young bulls.

In project (*a*) where the Zebu cross bull would be used on recorded dairy cows, the mechanism of the work would consist in producing the bulls, letting them out to a number of dairy farmers say twenty or more, for service, each one to say twenty-five of their recorded and known dairy cows, and subsequently purchasing the calves at fixed prices. These calves would be taken to the extensive project centre where they would be reared, and that centre would be equipped for raising and handling a large number of milking heifers as well as a large number of young bulls. It is unnecessary here to expand on the details of management, they would be uniform and the project is large scale. The writer believes this project could only be carried out in one of the southern states of the United States of America,

for nowhere else can one find a sufficiently large number of breeders with recorded pure bred cows, and consequently the Project Farm would need to be located there.

For project (*b*)—the use of proven sires on crossed Zebu dams—a venue in Brazil or India will have to be chosen, and some time may elapse before a large enough herd of females is gathered together. It is certain that it will be difficult to find a group of cattle owners with females of the breeding required, and thus the project itself may actually be more laborious, as the original heifers may have to be bred and raised before the proven sires are brought down.

A number of small herds of Zebu cross cows headed by proven bulls brought down from the United States will be required, and the offspring will need to be reared and tested for milk production. A considerable number of the young bulls will have to be kept also, until the heifer records have been obtained. Thereafter the project will be concerned with line breeding in the second cross.

Why it is felt that both projects are needed is because there is some slight evidence that the use of "European" bulls on Zebu type females gives a half bred animal which resembles the sire much more than the dam, both in conformation and milking capacity. But the evidence is very slender. The basic conditions vary. In tropical areas there are more Zebus and therefore more females of that type. In subtropical areas, there are well recorded herds, and there the "European" female is available in quantity. There may be some sex-linked inheritance—at present we are limited to general statements, admittedly born of observation, such as—the sire determines the shape, the dam has an influence on the internal set up and so on. The author believes that none of these statements made about cattle has any scientific basis.

In both of these projects the finding of individuals which show the desired characteristics will be the more laborious but the more certain the greater the magnitude of the experiment. By the use of artificial insemination it will be possible the more rapidly to increase the numbers of cattle carrying altogether, or in part, the breeding required.

The question arises: are the projects, which will be expensive, really worth while? Will it not do to go on in our present hit-and-miss fashion until by luck some breeder hits on the right thing, or until a group of breeders get together deliberately and purposely set out to do this work?

In view of the increasing importance attaching to the value of milk and milk products in human nutrition, and the need for incorporating the keeping of profitable livestock in conjunction with tropical agricultural operations, there is no question of the importance of the problem. The real question actually is will it pay to make a deliberate and controlled attempt to create a new strain or strains of tropical milking cattle suited to lower elevations in the tropical regions of the Americas? It is a contribution sorely needed, for we see the great attempts made by dairy farmers in these lower tropics to conduct dairy farming operations, using the highest possible grade of milking stock, under extreme artificial conditions. Practically the whole of the concentrate portion of the ration is imported, but debility of stock becomes apparent. The length of the service period, namely the period which elapses between calving and getting the cow in calf again, shows an increase. Vigour is what is lacking, that and the inability of an "improved" animal to be comfortable in the ordinary conditions of the lower tropics. Dairy farmers in the tropics shelter cattle, kill flies, keep the byres scrupulously clean, exercise the bulls, have cows served early in the morning, rear calves in such a way as to lessen the risk of infection by internal parasites and exclude the chance of pneumonia. They try to and do supply essential major and minor elements and food constituents according to the requirements of maintenance, increase and production. They import known and expensive feeding stuffs, and simulate as far as they can the treatment and feeding of dairy cows in what they think of as the better dairying regions of the world. In spite of all this, the improved dairy cow in the tropics fails to reach a reasonable standard of production from total nutrients fed. In some parts of the tropics dairy cows are taken to the "hills" to recuperate, some owners are using air conditioning. Others, recognising the uselessness of going up to too high a grade of European blood, regularly introduce common heifers and cows into their herds—in fact, in the herds there is a continual process of restricted grading up, and at the same time, by the practice of settling shy breeders by the use of Zebu bulls, there is an unsatisfactory process of grading down. The "blood" in the herds is in a state of a continual flux. The author is of the opinion that the tropics should have its own breed, breeds or strains, and that this problem should be tackled systematically in order to achieve the aim of greater certainty of productivity and profit from each individual bred, not high productivity from a few individuals. In Jamaica, where there are many experienced cattle breeders, they are well aware of the problem. A steadily increasing population must demand economical livestock, and so it is with many another tropical country. Ten years ago Hammond recommended the kind of programme sketched here—not on so large a scale however—with a view to producing a dairy cow for Jamaica; but no deliberate large scale attempt was made, which is a very great pity.

Rhoad, in a paper published under the auspices of the Union Pan Americana, has discussed the situation of dairy cattle breeding in Brazil. He shows in that paper and in an earlier one, that

crossing, back crossing, and grading up and down pervades the efforts of dairy cattle breeders in Minas Gerais. He has demonstrated the fact also that in these herds there are animals of above average production, and has shown their ability to respond to more continuous and exact supplementary feeding. There is always an attraction in isolating and grouping better specimens and breeding a superior herd, not only with the object of maintaining a better dairy herd, but also for producing bulls for use among commoner herds. It is assumed that this common sense approach to a solution of the problem is being pursued there. But it must be recognised that it does not give any reliable information as to how the foundation cow should be bred, or was bred. The bulls from such a herd will go out and be used presumably on cows of breeding simliar to themselves, but there is no certainty of this.

No attempt here has been made to work out the cost of the suggested projects—they would not be cheap, as a minimum of 400 original cows would be needed for each, requiring a minimum of 20 bulls to create the experimental animals in each project. Subsequently, uniformity of treatment to yield comparable results is essential and continuity of objective and of management is most important. Projects of this nature are long term and twenty-five years would be a reasonable period to set.

This paper does not pretend to cover the subject; it will have served its purpose if it arouses interest, and points the need to a thorough survey of the position. Several countries are interested, and it might well be best for representatives from them to confer on this and related subjects in order that the best lines of approach may be elucidated, and laid down.

DEVELOPMENT OF TIDAL SWAMP FARMING IN SIERRA LEONE *

EXISTING records show that for almost a hundred years rice growing has been continuously practised on the tidal lands of the Scarcies rivers in the north-west region of the Protectorate. In the southern and middle belt, where the normal practice of shifting cultivation, or a rotation of one year's cropping and 5 to 10 years' forest fallow, is general, grave concern is felt at the steady deterioration of the fallow crop. The soil is being worked out and no rotational system has been discovered to cure or even alleviate, this increasing evil. As a result of a survey of southern tidal areas, carried out in 1938-39, it was shown that some 230,000 acres of tidal swamp land were available for exploitation. Of this about 150,000 acres are mangrove forest and the remainder *Raphia* swamps and flooded grasslands. It was readily recognised that herein lay one possible solution for this part of the Protectorate and the Sembehun Agricultural Station was opened in this area early in 1939.

It should be pointed out that within this tidal swamp area there are some ten main rivers or creeks. Only on the banks of two of these rivers had an attempt, on a small scale, been made to cultivate rice in the mangrove swamps. The majority of the area thus possessed virgin and almost uninhabited mangrove forest. This forest is generally 100 per cent. *Rhizophora racemosa*, but under what appear to be less favourable conditions for the growth of this species, namely near the sea and to a lesser extent on the upper tidal reaches, *Avicennia nitida* is found. This species seems better able to withstand highly saline conditions and pure stands of considerable extent may be found near the sea. In general, well-grown *Rhizophora* may be taken as an indication that rice will flourish, but *Avicennia* areas should be tackled with caution. Towards the extremities of tidal conditions there is usually a stretch of *Raphia gracilis*, and sometimes *Pandanus*, between the mangrove and the normal mixed forest of the upland region.

The problem was to induce the farmers to grow their rice on the fertile swamps instead of the uplands. This sounds easy until it is realized that it involves a complete change in farming practice. They advanced many reasons for not utilizing tidal swamps. Typical reasons were the time-worn excuse that their fathers had not done so, the presence of devils in the mangrove forests and ignorance of the new farming operations involved. A very cogent argument was that they were unskilled in the technique of felling mangrove trees, and even if they had the money to engage expert fellers from the Scarcies region they would not want to spend it in that manner. Further, such a change must be on a considerable scale otherwise isolated farms would suffer from the concentrated attacks of various pests. The argument was reasonable and it was therefore suggested to Government that a fund should be established from which intending farmers could borrow money to engage tree fellers. This was approved and a Revolving Fund of £500 per annum was made available from which farmers could borrow money, they themselves providing two sureties, if they undertook, on the 3rd, 4th, and 5th year after receiving the loan, to make full repayment plus 10 per cent. interest on the capital. The reason for the lapse of two years before repayment begins is that mangrove trees normally take two years to rot and the first rice crop is usually taken in the third season after felling.

* Article by G. M. Roddan, Agricultural Officer, Sierra Leone, reprinted from *Farm and Forest*, 2, pp. 53-55, 1941.

Since the main object of the scheme is to encourage the people to leave the uplands and farm in the swamps, it follows that a movable population is available. As mentioned earlier many of the rivers and creeks are practically uninhabited. It was anticipated that the few towns along the rivers would increase in size, and that new villages would spring up on the uplands adjacent to the swamps. This development has already started. River transport is very primitive and very scarce and at planting and harvest times canoes are at a premium; the farmers, however, should be able to solve this problem for themselves.

Generally speaking, the *Raphia-Pandanus* stretch is capable of producing excellent crops of rice and, particularly in one area where the population was already housed near the swamps, small grants were made to assist farmers in brushing and stumping their farms. These grants were first made in 1939 and already, in this area, a stretch of 3 to 4 miles on both sides of the river is being cultivated by about 200 farmers. There is not a heavy silt deposit here and the more progressive of this group of farmers are brushing mangrove farms further down the river in case their present gold mine becomes worked out.

In the upper mangrove reaches the soil is often of a peaty nature and solid to walk on. It has been found that after deep-hoeing such land in the dry season a successful crop of rice can be grown the same year and after two years the ground appears to be in good condition for planting. The good mangrove land lower down the rivers requires no cultivation.

Mangrove perch are very troublesome in the upper reaches and, if rice is planted out on land which floods for any considerable time each tide, fences for protection against fish must first be made. These fences are constructed of *Raphia* leaves supported by stakes, or of loosely woven "mats" made from the leaf-stalk of *Raphia* or from bamboo cane. Monkeys and birds are other pests but the damage will be very considerably lessened when large contiguous areas are brushed: farmers are advised to form groups when felling.

The question of land tenure is not an easy one. In theory all land is vested in the Chief and Tribal Authority who hold it in trust for the people of the Chiefdom. Theoretically, therefore, we have "state" ownership but in practice there exists what is tantamount to private ownership. As far as mangrove land is concerned it is customary in native law that the first person to fell the forest becomes the recognized occupier of the area felled, and he and his descendants have a good claim to this land even if they do not cultivate it and allow the mangrove to grow again. In order to lessen the number of disputes over ownership which may arise in the future when tracts of new land are being brought into use, each farmer is required to pay a fee of five shillings into the Chiefdom Treasury for which he gets a receipt showing the position of his farm. At the moment amendments to native law are being pressed for and these may be made by the local Administrations. The first point is that the title to the land should only hold good so long as the land is cultivated by the original feller, and his heirs, to the satisfaction of the local Authority. It seems desirable that if land remains uncultivated for two successive seasons it should revert to the "State" in which case it could then be reallocated as if it were virgin land. It is also desirable that strict laws be made to prevent the sale, pledge, or assignment of land. If approved by the Tribal Authority, non-natives of the Chiefdom can, by payment of the five shillings fee, become tenants and exercise the same rights as natives.

The cost of felling naturally varies with the nature of the forest. For £1,000 given out on loan during the years 1939 and 1940 it is estimated that 1,300 acres were felled—an average cost of nearly 15*s*. 6*d*. per acre. Some farmers added private resources to their loans and about 20*s*. per acre can be taken as a reasonable cost for felling heavy mangrove forest. The average farm is about 5 acres but farmers will be encouraged to enlarge their farms gradually each year. A farm of 5 acres should produce about 100 bushels of "padi": half of this will be consumed by the farmer and his family, leaving him a cash income, at present rates, of about £7 per annum.

There have been disappointments but on the whole the scheme has been very favourably received. The method of farming is strange and clearly requires constant supervision and encouragement in the initial stages. The scheme will not stop at the distribution of money. New and improved varieties of seed rice will be distributed, and changes in farming practice, found to be advantageous on the Station Farm, will be advocated. Societies formed by groups of farmers for co-operative labour during the busy periods, and simple marketing societies to ensure that the farmer gets a better return for his labour, will be encouraged. Such societies will educate the farmers for the institution of the more advanced forms of co-operation which will doubtless follow.

From the Agricultural Officer's point of view the work is most satisfactory. The close personal contact with the farmers enables him to separate the sheep from the wolves so that in each Chiefdom he has a group of farmers he can rely on when new introductions are made. It is also one of the very rare instances where he can see immediate results from his labour.

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NOTES ON THERESIA CLARIPALPIS WULP (DIPTERA, TACHINIDAE), A PARASITE OF DIATRAEA SPP., IN TRINIDAD, B.W.I.

BY

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IN Trinidad, B.W.I., the indigenous Tachinid parasites of the small sugar-cane moth-borers, *Diatraea* spp., are *Theresia claripalpis* Wulp and *Stomatodexia diadema* Wied., the former being much the more important borer parasite. The Amazon fly, *Metagonistylum minense* Tns., was introduced into Trinidad in 1936 and 1937, but it is uncertain whether it has become established. *T. claripalpis* is a South American species, and has been recorded from Brazil, Argentina, Peru, Panama, Mexico, Venezuela, British Guiana and Trinidad. Different species of *Theresia* appear to be adapted to different ecological conditions. *T. claripalpis* is said to be a very adaptable species occurring over a wide climatic range, but to be best suited to humid conditions and an open region light rainfall environment.

In Trinidad *Diatraea impersonatella* Wlk. is the most important moth-borer of sugar cane, especially in the south. *D. canella* Hmps. is apparently more abundant in the north than the south. *D. saccharalis* F. is comparatively rare, and is more common in mature canes than in young shoots. *T. claripalpis* has been recorded as attacking a considerable number of hosts. In Trinidad it has been shown definitely to prefer *D. impersonatella* and *D. saccharalis* to *D. canella* in the same host plant.

Studies on parasites have shown that, in certain species at least, there appear to be races differing in their temperature reactions, which suggests the possibility of selecting or developing strains of parasites that would be useful in areas outside their normal range. The European corn borer, *Pyrausta nubilalis* Hb., and the sugar-cane moth-borers are very similar in their life-histories and habits, and the entomologists at the Dominion Parasite Laboratory in Canada were anxious to find whether any of the Tachinid parasites of *Diatraea* would at least reproduce on the European corn borer. If liberated in Canada, the chance that these parasites would become acclimatized was of course very remote, but it was thought that this difficulty might possibly be overcome by the selection of strains suited to the Canadian climate.

Arrangements were therefore made for *T. claripalpis* to be collected in Trinidad and sent to Canada for this purpose. Three field assistants were engaged for the work for eight weeks from 23rd June to 16th August, 1941, and the field collection was made on Caroni estate by courtesy of Caroni Estates Ltd. Expenses were paid by the Canadian Government. Shipment was made from Trinidad to Canada by Pan American Airways Inc. and connecting airlines via the United States under permit from the United States Department of Agriculture. The parasites were consigned to Dr. W. R. Thompson, F.R.S., Director of the Imperial Parasite Service, who passed them on for the breeding experiments to the entomologists at the Dominion Parasite Laboratory. Dr. Thompson kindly informs me (*in litt.* 1941) that the parasites were received alive in Canada, where they were successfully mated in the laboratory by Mr. G. Wishart. He also states that one generation was bred through successfully on the European corn borer, showing with certainty that *T. claripalpis* can reproduce on this host.

All of the *Diatraea* larvae for the rearing of parasites were obtained from sugar-cane "dead hearts" and no mature canes were cut. The procedure was to cut "dead hearts" in the field and transport them to the laboratory, where they were dissected, any "field collected" larvae or puparia of *T. claripalpis* removed, and the *Diatraea* larvae isolated in 8 ins. by 1½ ins. glass test-tubes plugged with cotton wool. From 2 to 3 larvae were placed in each glass tube with a piece of freshly cut cane as food. The tubes were examined daily, fresh food added, and any "lab reared" larvae or puparia of *T. claripalpis* removed.

In all 18,497 "dead hearts" were cut in the field and dissected in the laboratory, and yielded a total of 4,232 *Diatraea* larvae. Of these 2,927 (69.2 per cent.) were *D. impersonatella*, 1,260 (29.8 per cent.) were *D. canella* and 45 (1.0 per cent.) were *D. saccharalis* (*see* Table 1).

In all 399 *T. claripalpis* were obtained. Of these 231 were "field collected", obtained by dissection of "dead hearts", and the species of *Diatraea* which they attacked was therefore unknown. The remaining 168 were "lab reared", obtained by isolation of parasitized *Diatraea* larvae in the laboratory, and the host species was therefore known. The 168 "lab reared" parasites comprised 159 from *D. impersonatella* 5 from *D. canella* and 4 from *D. saccharalis* (*see* Tables 1 and 2).

Table 1

NUMBERS OF 3 *Diatraea* SPP. AND *Theresia claripalpis* WULP OBTAINED FROM SUGAR-CANE "DEAD HEARTS" AT CARONI ESTATE FROM JUNE TO AUGUST, 1941.

Caroni estate field	No. of dead hearts	No. of *Diatraea* larvae	No. of *Diatraea* pupae	No. of *D. impersonatella* larvae	No. of *D. canella* larvae	No. of *D. saccharalis* larvae	No. of *T. claripalpis* larvae and puparia
McLeod Plain 1	1,885	213	33	101	107	5	26
McLeod Plain 2	2,139	884	57	601	281	2	56
McLeod Plain 4 & 5	350	68	0	8	60	0	0
McLeod Plain 8	1,754	281	47	227	54	0	20
McLeod Plain 9	805	108	21	70	38	0	7
McLeod Plain 19	1,200	247	30	162	85	0	25
Frederick 48	876	172	9	86	85	1	19
Frederick 70	600	174	0	141	32	1	3
Frederick 74	500	121	0	76	36	9	0
Frederick 75	1,374	427	31	276	151	0	24
Frederick 80	840	126	17	73	52	1	10
Frederick 88	5,157	1,127	74	995	108	24	203
Washington 26	465	95	8	50	45	0	3
Washington 28	552	189	0	61	126	2	3
	18,497	4,232	327	2,927	1,260	45	399

The relative numbers of the 3 *Diatraea* spp. parasitized by *T. claripalpis* clearly indicated the host preferences of the parasite. *D. saccharalis* and *D. impersonatella* were parasitized to the extent of 8.9 per cent. and 5.4 per cent. respectively, while *D. canella* showed a parasitism of only 0.4 per cent. (*see* Table 2).

Table 2

PARASITISM OF 3 *Diatraea* SPP. BY *Theresia claripalpis* WULP.

Host species	No. of host larvae	No. of parasites reared	Parasitism per cent.
D. impersonatella	2,927	159	5.4
D. canella	1,260	5	0.4
D. saccharalis	45	4	8.9*

* Parasitism expressed as a percentage with some reluctance in view of the small numbers involved.

T. claripalpis was the only Tachinid parasite found attacking *Diatraea* spp. at Caroni estate, neither *Stomatodexia diadema* nor the Amazon fly, *Metagonistylum minense*, being obtained. The latter species was introduced into Trinidad in 1936 and 1937 by Mr. A. Pickles, Trinidad Government Entomologist, and liberated at a number of places including Caroni estate. At Mr. Pickles' suggestion, "dead hearts" were cut, as far as possible from those fields where actual liberations had been made (*see* Table 1). The fact that no specimens of the Amazon fly were obtained from so extensive a survey suggests that this parasite has not become established at Caroni estate.

As soon as either "field collected" or "lab reared" puparia of *T. claripalpis* were obtained, they were placed in cool storage from 65–75°F. to retard development. They were sometimes kept under these conditions for as long as a week until a sufficient number was obtained for shipment. This treatment apparently had no harmful effects and did not impair subsequent emergence.

The puparia were shipped in tin cans 5 ins. in height and 5 ins. in diameter with well fitting lids. Two methods of packing the puparia were used. In the first, a cardboard disc was firmly fixed in the bottom of each can, and to this disc from 12 to 24 puparia were carefully glued with gum arabic. The space within the can was provided for any flies which might emerge in transit. In the second, which was the simpler and more successful method, a disc of damp blotting paper was placed in the bottom of the can and above this a quantity of dry crumpled tissue paper. From 12 to 24 puparia were loosely packed in this paper, above which was firmly fixed a cardboard disc. This disc acted as a partition and was provided with openings to allow the passage of any flies which might emerge into an open space above. In both methods food was provided for any flies which might emerge during shipment. This consisted of a few crystals of refined sugar, a few split raisins and a disc of blotting paper

soaked with honey and water fixed within the lid of the can. The cans were packed in a cardboard box with plenty of excelsior both to prevent jarring and to act as insulation against extremes of temperature.

In all 315 puparia of *T. claripalpis* were sent in 6 shipments to Canada by Pan American Airways Inc. and connecting airlines, the journey taking some 30 hours from Trinidad to Ontario, Canada. That a sufficient number of flies emerged to enable breeding work on this parasite to be done in Canada, is in no small measure due to the work of the field assistants in Trinidad and to the care with which Miss P. Atteck packed the puparia for shipment.

Summary

1. At Caroni Estate, Trinidad, B.W.I., 18,497 sugar-cane "dead hearts" were cut in the field in 1941 and yielded 4,232 *Diatraea* larvae.

2. *Diatraea impersonatella* Wlk. was the most abundant moth-borer ; 69.2 per cent. of the moth-borers were this species, 29.8 per cent. *D. canella* Hmps. and 1.0 per cent. *D. saccharalis* F.

3. *Theresia claripalpis* Wulp was the only Tachinid parasite found ; neither *Stomatodexia diadema* Wied. nor the Amazon fly, *Metagonistylum minense* Tns., were obtained. It is suggested that the Amazon fly (introduced into Trinidad in 1936 and 1937) has not become established at Caroni Estate.

4. A total of 399 puparia of *T. claripalpis* were obtained ; 231 were "field collected" and 168 "lab reared".

5. *T. claripalpis* showed a distinct host preference for both *D. saccharalis* and *D. impersonatella* ; 8.9 per cent. of *D. saccharalis* were parasitized, 5.4 per cent. of *D. impersonatella* and 0.4 per cent. of *D. canella*.

6. A successful method of shipment of live puparia of *T. claripalpis* from Trinidad to Canada is described.

THE "ORANGE MOTH" OF DOMINICA, B.W.I.

BY

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Introduction

SINCE 1910 certain orange estates situated in the upland parts of Dominica, at elevations of over 1,000 feet, have from time to time been reported to suffer a small seasonal loss of fruit as a result of the attacks of an "Orange Moth", the larva of which bores into the developing fruit, and thus affords entry for various fungi. Such fungi cause yellowing of the skin around the point of entry, and subsequent shedding of the fruit. It was noted by early observers in the course of various unsuccessful attempts to rear specimens of the moth that fruit, though marked with an entrance hole, usually contained no larvae, or that when small living larvae were found, they died before pupation. In 1938 the writer was able to take up this problem and in a series of visits extending up to July, 1941, obtained the data presented below. The successful outcome of this investigation was due in large measure to the exceptional opportunities for study made possible by the hospitality of Mr. S. L. Vaughan Green, of Roseau, to whom the writer's thanks are cordially tendered.

Distribution, Host Plants, and Economic Status

The "Orange Moth" has been assigned by Dr. Carl Heinrich to the genus *Gymnandrosoma* (Olethreutidae), being probably a new species near *G. trachycerus* Forbes. *G. trachycerus* has been described from Puerto Rico, but apparently has not been found to damage fruit. Another species, *G. aurantianum* Costa Lima, is known as something of a pest of citrus fruit in Brazil.

The Dominican species is naturally confined to mountain rain-forest, and lives, in the larval stage, in various smooth-skinned fruits. In late May or early June, as the first crop of oranges is developing, a large population of *Gymnandrosoma* infests the fruit of *Simaruba amara* (Simarubaceae), a forest tree locally known as "Bois blanc", used for its timber and for making charcoal. The citrus which the moth attacks includes Washington Navel Orange, Sweet Lime, Portugal and Tangerine.

Gymnandrosoma occurs only locally on citrus in Dominica. Losses of Washington Navel Orange in affected areas are small, probably rarely exceeding 1 per cent. of fruit picked. Sweet Lime and Portugal have been found more heavily infested, while a very small group of Tangerine has been reported to suffer fruit losses reaching 50 per cent. When the writer examined these trees in 1938 the proportion of the crop then affected was approximately 20 per cent. There is little doubt, however, that these figures are determined not by preference on the part of the insect but by accident of location as the trees were situated at the edge of the forest, close beneath the fringe of the canopy.

Life History

The Egg

The egg is 1.3 mm. in diameter, flattened and circular. The surface is hyaline and glossy, minutely and confluently rugose. At oviposition, it is plastered to the surface of the fruit, where it persists long after hatching has occurred, readily discernible by its strongly reflective surface. On oranges it is usually placed on the hemisphere near the flower end of the fruit, but rarely at the flower base itself. The eggs, which are laid singly, are generally found on fruit about 1½ inches in diameter. This is probably due not to any preference but to the time of emergence of the moth coinciding with this stage of development of the orange crop. On fruit of "Bois blanc" the egg is laid almost anywhere, even at the distal apex. Normally only one egg is laid on a single fruit, though as many as four have been noted. The larva hatches in about five days, and emerges through a marginal tear. It was found that less than 1 per cent. of eggs failed to develop after oviposition.

The Larva

On hatching the larva is 0.8 mm. long, transparent, with a brown head and prothoracic plate. At the end of the growing period it is 13 mm. long with a head width of 1.5–1.7 mm. The head and prothoracic plate are brown-black, and devoid of markings. Primary setae only are present. The derm is colourless and is underlain by pigment cells of a reddish purple hue, somewhat irregularly grouped, while the body contents below this are a greyish cream. The crochets on the prolegs are arranged in a biordinal ellipse. The larval stage lasts about three weeks.

Larval Habits

When the egg has been laid on fruit of "Bois blanc", about 10 per cent. of the larvae, on emergence, burrow immediately into the pulp. Others enter near one pole. Most larvae feed in the outer fleshy pulp for a time, then bore through the thin shell of the seed and reach the underlying cotyledons. Fungal rot sets in at the point of entry, but as the fruit is immature when attacked, does not make rapid headway. It is usual for fruit to fall during the period of infestation whereupon a secondary association of Mycetophilid and beetle larvae develops in the pulp. In an examination of several thousand fruit it was repeatedly observed that larvae which fed on the pulp failed to grow to the size attained by those feeding on the cotyledons. It is in the former group that the heaviest larval mortality occurs, most probably as a result of the greater exposure to enemies when the fruit is on the ground. Those inside the cotyledons are relatively free from molestation owing to the partial shelter offered by their burrows and to their pugnacity. The larvae have a considerable tolerance of putrescence in the fruit, and have regularly been taken from seeds in an advanced stage of breakdown. Only one larva completes its development inside a single fruit. A Braconid parasite (*Bassus* sp.n.) has been reared from larvae infesting fruit of *Simaruba*, but it did not affect more than 5 per cent. at the time of examination.

As occurs in other Olethreutidae, pupation takes place inside a cocoon formed of a dense web of silk built over a hole or crevice in the substratum, and concealed with particles which have been bitten out and placed on the web. When pupation occurs inside the fruit, portions of kernel are used for this purpose but in the laboratory paper, wood, and silk were accepted readily as substitutes. The cocoon is frequently constructed so that the pupa lies at the mouth of the feeding tunnel, while the exit is protected by a funnel-like projection of silk, closely studded with débris. This funnel is sometimes carried outwards until it can be affixed to an adjoining fruit, thus producing a 'wedded' seed. It is more usual for larvae to leave the fruit before pupating and to use any crevice near at hand.

It is interesting to compare these habits with the behaviour of larvae emerging from eggs laid on oranges. After hatching, the larva wanders round the fruit, sometimes for several hours, without attempting to make an entry. Judging from the number of hatched eggs unaccompanied by any mark of boring in the fruit it would seem that larvae often fall off, or migrate down the stem and die. It may be that the wandering is due to the absence of an olfactory or tactile stimulus to burrow. An experiment was carried out in which larvae, hatched from eggs laid on citrus, were allowed to wander around the fruit for an hour. In this time they made no effort to burrow, and moved round the fruit without pause. They were then confronted with a shallow trough, 2.5 mm. long and 3 mm. wide, from which the epidermis and oil cells had been thinly removed. Two of the larvae, after a momentary pause, began to bore downward ; a third walked along the edge of the depression, then finally made its entry into the pith. Two other larvae, which had passed the excised area, began to bore downward as soon as they encountered it on the following round.

Once inside the fruit, most of the larvae burrow into the cells of the pulp and are drowned in the juice. Of those which enter young Portugal oranges and confine themselves to the pith, many are killed by the gum which exudes at the point of injury. If it avoids these mishaps, the larva feeds for a time in the pith and then bores towards the centre, where it eats the 'rag'. As it grows it is able to traverse the pulp with safety. The fruit, by that time, has fallen from the tree and has partially dried. Where large fruit have been invaded, rotting sets in quickly after shedding, and the larva before its final moult tunnels freely about the decaying mass among swarms of saprophagous beetles and Drosophilid flies. In small dry fruit lying on the ground pupation may occur

in the feeding tunnel. In all other conditions the larva spins its cocoon elsewhere. The mortality of larvae in fruit of *Simaruba*, estimated from 1,000 fruit, was almost exactly 90 per cent.; of those in orange, estimated from 50 fruit, it was 92 per cent. The larva rests for several days inside the cocoon before pupating.

The Pupa

The pupa is reddish brown, 9.6–12 mm. long, 2.7–3.0 mm. broad across the thorax, and 2.1–2.3 mm. in depth. The tergum of each abdominal segment bears two transverse rows of spines directed posteriorly, of which those in the first row, numbering approximately 20, are individually larger than the 40 in the second. At the end of the abdomen are six radial spines. Approximately 14 days are passed in the pupal stage. At dehiscence the pupal case is moved from side to side and is thrust forward by the action of the spines until it projects from the tunnel at the fore end of the cocoon, where it is left when the imago escapes. Adults develop in and emerge safely from about 99 per cent. of pupae.

The Adult

The imago (Fig. 1) is approximately 7.5 mm. long, with a wing span varying around 17.0 mm. The antennae, head, thorax, and the outer aspect of the legs, and all but the anterior margin of the hind wings are dark brown; the palps, cream and black; the abdomen, silvery buff mottled with dark brown. The forewing varies from an intensely dark brown to a conspicuously variegated pattern of brown-black and cream. The basal pattern of brown-black consists of a recurved crescentic area beginning two-thirds from the base of the anterior margin, and curving posteriorly towards the wing base. Beyond it, near the apex is a trapezoidal patch of cream. A dark patch occurs near the base of the wing, and black spots are situated along the costa. The remainder of the wing is mottled with purplish-red-brown, black, and slate.

By day the moth rests under leaves, on bark, etc., and mating and oviposition occur principally in the hours shortly preceding midnight. An adult female was kept alive for four days, and in the field it is likely that the effective life—the period during which oviposition is maintained—is confined to a few nights after emergence. Where pupation has taken place in "wedded" seeds or elsewhere on the ground, in the immediate vicinity of orange trees the adult moths are likely to encounter the fruit frequently, as they emerge about early June. Moreover, towards the end of the month the supply of *Simaruba* seed begins to fail, and dispersal of *Gymnandrosoma* to a new host becomes imperative. There is every reason to believe that citrus is not a regular host in the annual sequence, and, as the incidence has not increased during the last twenty years, as far as can be judged from earlier estimates, the crop as a whole does not appear to be in any immediate danger, though the possibility always exists that a "physiological race" may arise which would embrace citrus in its normal host range.

Estimate of Population in the Field

An estimate was made of the population of *Gymnandrosoma* females which after mating would be able to oviposit on citrus in a small selected field. The number of "Bois blanc" in the windbreaks surrounding three sides of an orange field was counted. On two sides the windbreaks were narrow, lipping the edge of steep slopes; on the remaining side trees were counted to a depth of 20 yards into the forest from the edge of the field. The total number in a fruiting condition was found to be thirty-seven, all of reasonably uniform size. One of the trees, an average specimen, was felled on to open ground and a hand count was made of the number of fruit. The total, including fallen fruit and a 1 per cent. addition for fruit not found, reached 9,500, from which a figure of approximately 350,000 was obtained for all the windbreaks. Of the total, including fruit picked from the ground, 23.4 per cent. were infested with *Gymnandrosoma*, indicating that approximately 81,900 fruit were infested around the field. It has already been noted that only 10 per cent. of larvae reach the pupal stage and that about 1 per cent. of pupae fail to hatch. There would thus be 8,190 pupae formed and the resulting imagines would total approximately 8,100, from which some 4,000 females would be available to infest the citrus.

A survey of the field inside the windbreak showed that the greatest infestation, on the whole, occurred on oranges growing near the windbreak. Of approximately 200 fruit inspected in the first or second row near the windbreak 10 carried an egg while 7 were infested. As the hatched egg remains on the fruit indefinitely this estimate can be accepted as covering the total laying for the season up to this time.

If it be assumed that each egg was laid by a different female, and egg-incidence remained constant near the windbreak at 5 per cent.,* not more than 50 females would alight on each 1,000 fruit in these rows. Farther away from the windbreak a survey of 500 fruit yielded only 4 damaged specimens (.8 per cent. infestation), on which basis only eight females would oviposit on every 1,000 fruit away from the windbreak. Thus, estimating 5,000 fruit as the potential yield of the field including 1,000 fruit from the outermost rows, about 80 females out of 4,000, or approximately 2 per cent. of the female moth population would oviposit on the citrus. If it be assumed that each female lays more than one egg on citrus—as is not unlikely—the percentage of females is still lower. It is reasonable

* The estimate was made at a time when the emergence of the *Simaruba* generation of moths was considered to be in full progress.

FIG. 1.—1. *Gymnandrosoma* sp. near *trachycerus* Forbes (Olethreutidae).
2. *Bassus* sp. n. (Braconidae).

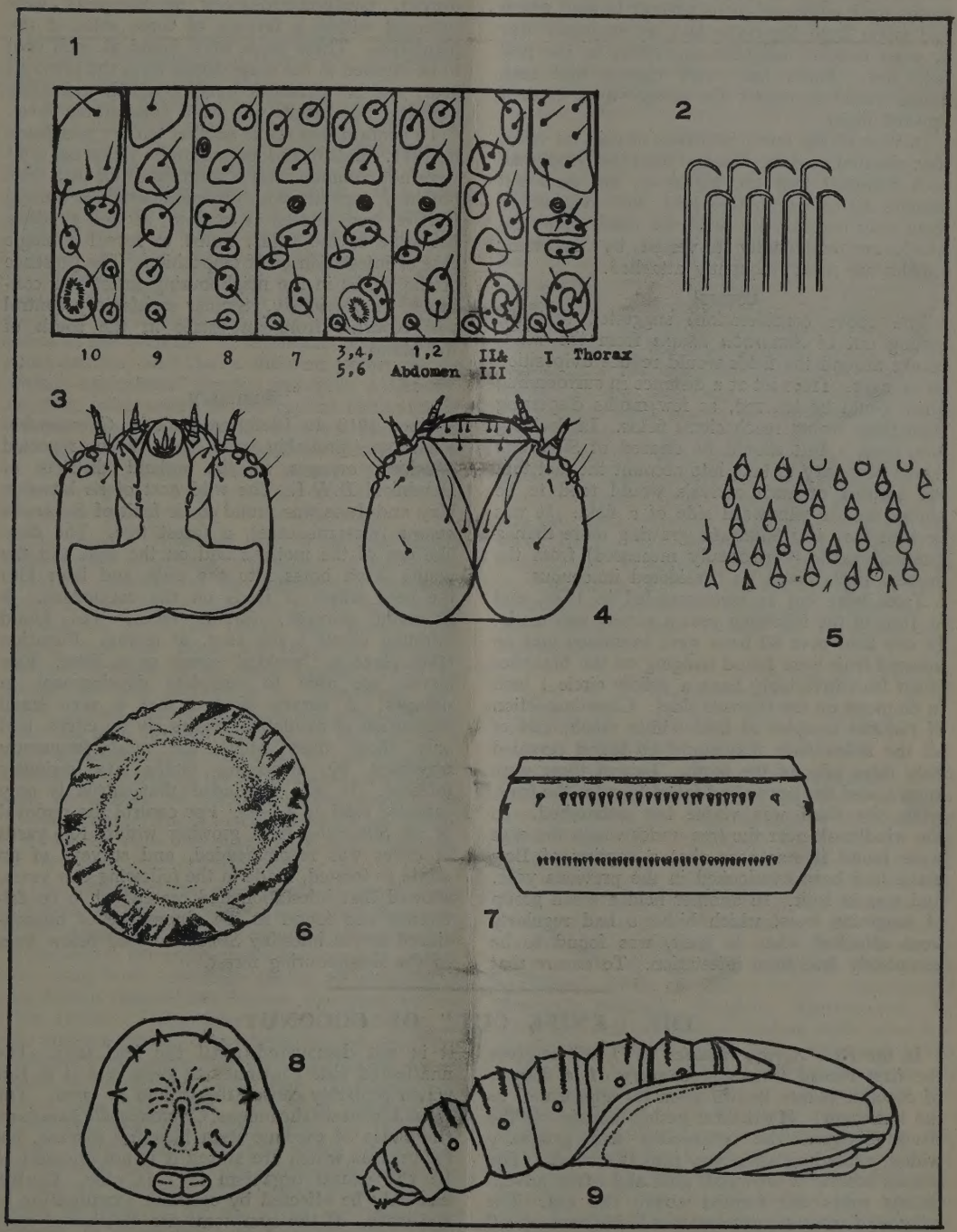

FIG. 2.—1. Setal map of larva. 2. Crochets of proleg. 3. Head of larva, ventral view. 4. Head of larva, dorsal view. 5. Portion of epidermis, highly enlarged. 6. Egg, dorsal view. 7. Abdominal segment of pupa, dorsal view. 8. Pupa, posterior view. 9. Pupa, side view.

to consider that this 2 per cent. represents a small aberrant group of the population. Several hundred moths were estimated to be present in seed which had fallen from *Simaruba* and lay scattered near or even beneath neighbouring citrus in the first field row. There was every chance that such moths would encounter the orange trees in their upward flight.

In view of the lower incidence of eggs on citrus fruit situated at some distance from the windbreak it is assumed that the moths do not seek out oranges as an alternative host, but oviposit on them only occasionally, with the result that trees which are continually traversed by dispersing females are most frequently attacked.

Control

The above considerations suggested that the cutting out of *Simaruba amara* from the windbreaks around the fields would reduce oviposition on oranges. Trees set at a distance in surrounding forest could be ignored, as few moths dispersing from them would reach citrus fields. In deciding how deep a belt should be cleared of *Simaruba* it was necessary to take into account the fact that the number of such arrivals would tend to be higher on the windward side of a field. It was decided that any *Simaruba* growing more than a hundred yards (horizontally measured) from the nearest citrus could be considered innocuous.

Trees were cut as recommended in 1939, and in June of the following year a survey was made. In one field over 80 trees were examined and no infested fruit were found hanging on the branches (such fruit invariably have a yellow circle 1 inch in diameter on the exposed side). Close inspection of random samples of fruit within reach, and of all the fallen fruit that could be found revealed only three eggs of the moth. Two of these were empty, and the larvae had failed to enter the fruit, while the third was viable but unhatched. In the windbreak near the tree under which the eggs were found it was seen that a sapling of Bois blanc had been overlooked in the previous year, and was in fruit. In another field a small group of tangerine trees, which hitherto had regularly been attacked when in fruit, was found to be completely free from infestation. To ensure that this result was not due to a chance fluctuation in the population of *Gymnandrosoma* in the whole district, newly-fallen seeds of *Simaruba* were collected within a furlong of three sides of the plantation. These seeds were found at each spot to be infested to the same degree as in the previous year, and no parasites were obtained, indicating that the population was at a comparable level.

To confirm this result another survey was made in 1941. Fallen and prematurely yellowing fruit were not common, and a scrutiny of all that were obtained, together with an examination of normal fruit on trees chosen at random, as well as along the edge of the fields, failed to reveal a single case of infestation or of oviposition. The presence of the moths in the neighbouring forest was confirmed as previously. Similar satisfactory control was reported from an estate in the south of the island.

Summary

Since 1910 an Olethreutid moth, *Gymnandrosoma* sp. probably new, has been reported attacking oranges in the upland districts of Dominica, B.W.I. The wild host of its larva in May and June was found to be fruit of *Simaruba amara* (Simarubaceae), a forest tree. The disc-like egg of the moth is laid on the skin and the young larva bores into the pulp and later into the seed where it feeds on the cotyledons. A Braconid parasite, *Bassus* sp.n., was found infesting about 5 per cent. of larvae. Pupation takes place in "wedded" seeds or in litter. Few larvae are able to complete development in oranges. A survey showed that a very small proportion of available females lay on citrus, and only those trees which are most frequently traversed by dispersing moths are seriously infested. It was concluded that citrus is only casually used as a host. For control the removal of all *Simaruba* trees growing within 100 yards of citrus was recommended, and surveys of an estate so treated, made in the following two years, showed that infestation had ceased, while no difference was found in the abundance of unparasitised larvae infesting *Simaruba* seed below trees in the neighbouring forest.

THE "KNIFE CUT" OF COCONUT

In the *Rev. Agric., Maurice*, P. O. Wiehe gives the first record from any country of a disease of coconut plants known from its appearance as the knife cut. Horizontal gashes appear on the trunk between the internodes and gradually widen, extending some way into the trunk. The lesions secrete a brownish gum and often adventitious roots are formed above the cut. The crowns of trees so attacked are liable to snap off in strong winds or disease organisms can gain entry and yield usually diminishes. The cause of the disease is unknown but it probably starts at a spot where the growing point of the palm is still soft and shielded by the leaf stalk and so it is not discovered until the leaf falls. The unaffected side continues to grow and it is this which probably causes the wound to open. The wounds contain the fungus, *Ceratostomella paradoxa*, the cause of coconut stem bleeding disease, but for reasons which are stated it is not thought to be the causal organism in this case. Control can only be effected by constant examination of the trees. If the symptoms are discovered early the lesions can be cut out, and the affected part cauterized by heat and then tarred. The cavities should be filled with cement. A somewhat similar disease is found in sugar cane.—(*Horticultural Abstracts*, XI, No. 3, 1941.)

REVIEW

SONS OF THE SOIL

Studies of the Indian Cultivator edited by W. Burns. Government of India Press, 8, Hasting Street, Calcutta. Price 4s.

This book, published by the Imperial Council of Agricultural Research, India, and edited by Dr. W. Burns, C.I.E., Agricultural Commissioner with the Government of India, is indeed a new type of official agricultural textbook. It is professedly written for the "cold-weather" visitor or business man who looks across the fields, sees the farmers at work, and asks himself, as he is bound to do if he thinks at all, "what are these people really like, what is their life, what do they talk about when they chat with their neighbours in the evening ?" It consists of a series of short articles, each by a different officer of the Indian Agricultural Service, generally a Deputy-Director, who writes of the typical cultivator of his own districts. A really excellent photograph and a couple of pages of verbal account are given of a typical member of each of some 40 farming tribes or castes. Each province and also Burma is represented by some of its cultivators.

The result is to present even to the most superficial reader a striking impression of the extraordinary diversity of the agricultural tribes of India in their whole character and in their whole outlook on life. The reader who delves more deeply into the book will find an accurate, succinct account of his local farmer, which he would be hard put to it to glean from any other printed matter. And he will probably find that the man he sees working in the field is a very different person from what he had imagined. Incidentally many of the articles also give thumb-nail impressions of the agricultural methods of various parts of India—methods which are hardly less diverse than the appearance and characters of the tribes that practise them.

The writing of the articles has obviously been a labour of love for the authors, and their tone is a testimony to that creed of friendly and appreciative sympathy with the peasant, which has long been a tradition among all members of the Indian Agricultural Service, European no less than Indian. The articles are also a testimony to the authors' powers of condensation, for only very extreme compression has made it possible for so much to be covered by so little. To their credit be it also said that they have avoided the Baedeker style of writing. But, on the other hand, every sentence of some of the articles conveys a solid fact ; and one cannot help wondering if they will not make rather heavy reading for the kind of reader — the magazine and newspaper reader—to whom the book is addressed. And it is really sad that the prospective reader of such an otherwise excellent book should be repelled, as he surely must be, by a serious eruption of that disfiguring and painful disease that mars so many books about India—an abundant rash of vernacular words. On some pages of the book there are as many as twenty of these sores, at least nineteen of which could have been avoided. No doubt *baithakhana* conveys a slightly different meaning from the commonest sense of "sitting-room", and a *pancha* may differ from the commonest modern forms of "council", *rabi* from "winter", *gur* from "treacle" and so on ; but surely these English terms are near enough for a book of this kind ? One or two of the authors try to palliate the disease by the application of the nearest English equivalent in parenthesis after the vernacular word, or *vice versa*: others try laboriously to convey the approximate meaning of the vernacular word without actual parenthesis. It is a nice question which of these palliatives is the least objectionable ; but to one reader, at any rate, any of them is as bad as the disease. Only one or two of the authors earn our gratitude by restricting their use of the vernacular to the very few occasions when it is excusable, that is when it is impossible to translate the Indian word reasonably well by one English word or even by a phrase of two or three words. Such vernacular words, which will then be few in number, might well be dealt with in a glossary. For an explanation of the exact meaning of those terms, taking up perhaps two or three lines of print, would be interesting and instructive.

O.T.F.

IMPERIAL AGRICULTURAL BUREAUX CENTRAL SALES BRANCH

Specialists in the various branches of agricultural research and teaching will be interested in a new development in the organization of the Imperial Agricultural Bureau. Some time ago it was decided that, for the sake of increased efficiency and economy, all work connected with subscriptions, sales, and distribution of the journals and other publications of the majority of the Bureaux should now be centred in one office. For this purpose, a Central Sales Branch has been organized, with its offices at the Agricultural Research Building, Penglais, Aberystwyth. In future all correspondence dealing with sales and distribution should, with the exceptions noted below, be so addressed. Correspondence on all other matters must still be addressed to the Deputy Director of the Bureau in question.

The only publications not dealt with by the Central Sales Branch are those of the Imperial Institute of Entomology (The Assistant Director, Imperial Institute of Entomology, 41, Queen's Gate, London, S.W.7) and the Imperial Mycological Institute (Director, Imperial Mycological Institute, Ferry Lane, Kew, Surrey), and *Nutrition Abstracts and Reviews* (Secretary, Imperial Bureau of Animal Nutrition, Rowett Institute, Bucksburn, Aberdeen).

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Tung-Oil Tree Cultivation in India

Experiments in the cultivation of the tung-oil tree in the British Empire were first initiated by the Imperial Institute in 1917 in India and a number of Colonies, but they were inconclusive. In 1927 the matter was taken up again by the Advisory Committee of the Institute in collaboration with the Director of Kew and the Director of the Research Association of British Paint, Colour and Varnish Manufacturers; seed was obtained from China and Florida and distributed to various countries of the Empire. It is said that there are now grounds for considering that, so far as India and Burma are concerned, the industry can be developed either as a self-supporting one, in view of the growing commercial importance of tung-oil, or as a cottage industry in places where the plants can be easily grown and seeds marketed, or in tea-gardens as a subsidiary industry. This opinion is based on the fact that experiments have now been carried out for two decades with varying measures of success in localities in India and Burma and in Ceylon, Malaya and East and South Africa. There are market competitors in drying oils such as Perilla oil, Viticica oil and Po-yok oil, although they are inferior, while recently synthetic resins have been developed which may reduce the use of tung-oil in process work, one of the latest developments being a castor oil derivative.

* * *

Lignin

It is estimated in a note recently published in *Time* (Vol. 39, pp. 28–29) that the supplies of synthetic rubber in the U.S.A. may be stretched from two to five times by generous admixture of lignin, while the supplies of plastics can probably be doubled by adding lignin. Recently the use of lignin—itself a plastic as well as a plastic "extender"—has increased four-fold in making aeroplane pattern plates. In spite of a good deal of research chemists have so far found uses for less than .05 per cent. of the 3,000,000 tons of lignin available each year in the U.S.A. and Canada. Yet lignin production goes on, for it must be removed from the wood pulp before the pulp is made into good sulphite papers.

Lignin which is a dark, resinous substance, constitutes about 25 per cent. (by weight) of the coniferous trees from which most paper is made. Every day some 12,000,000 gallons of lignin waste are drained from the vats of U.S. mills which find it very hard to get rid of this waste. In some mills it is expensively dehydrated and burnt. One well known mill, after many years of research devised a process by which, through the addition of lime, waste liquors can be precipitated out into calcium lignin sulphonate. This in turn has been converted into: vanillin, the flavour constituent of vanilla; tanning chemicals; agents which disperse cement more efficiently through sand, gravel and water; water softening agents which are used widely in locomotives; and plastics. The plastics are produced in both common forms: (1) moulding powders from which odd-shaped objects are pressed; (2) laminated sheet—*i.e.* layers of paper or cloth bound together and coated with lignin derivatives—which are used in such simple large-surface products as tabletops, refrigerator and aeroplane doors. Laminated lignin plastics are one-half the weight of aluminium, one-fifth the weight of steel. Pound for pound they are as strong as steel. The expanding U.S. output of lignin plastics can be used almost entirely for military purposes, *e.g.* parts of ships, tanks, planes, bomb fuses, cases for shipping shells, insulators. Lignin plastics are the cheapest plastics yet devised; at 5 cents per lb. for the powder they cost only one-third to one-fourth the cost of most synthetic resins. But to-day they have a still greater advantage—they require as little as 2 or 3 per cent. phenol (carbolic acid), a chief component of the commonest plastics and now a badly needed, ingredient. Furthermore, lignin moulding powders can be mixed to "extend" phenol plastics by 100 per cent., synthetic rubber for many uses by 100 to 500 per cent. As a road-binding material, lignin is now widely used in U.S.A.

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Coffee Manurial and Mulching Experiments

An account is given in the *Malayan Agric. J.*, Vol. XXIX, p. 68, of a coffee manurial experiment laid down in 1933 at the Experiment Station, Serdang, and of a mulching experiment superimposed on part of this in 1938.

A. Coffea liberica.

Rock phosphate at 4 cwt. per acre per annum gave a mean increase of 26 per cent. This rose to 55 per cent. when 2 tons of green manure per acre per annum were added to the above. Small amounts of N and K in conjunction with phosphate gave no further increases. The mulch consisted of grass and leaves applied at the rate of 10 tons per acre every 6 months. The layer was 3 to 4 inches deep and covered all the ground. The bushes improved in appearance after 4 months. No increase in yield occurred till the second 12 months, when 127 per cent. was obtained. Mulch alone has given an increase of yield 55 per cent. better than that of the best manurial plots. It is noted that a mulch using only half the quantity of material produced an increased yield of 101 per cent., the full mulch therefore giving only an additional 26 per cent.

B. Coffea robusta.

This species does not grow well at Serdang. It has not responded to manures but mulching increased yield in the second year by 59 per cent.